
Elizabeth A. Masterson, PhD1; P. Timothy Bushnell, PhD2; Christa L. Themann, MA3; Thais C. Morata, PhD3

Hearing loss is the third most common chronic physical condition in the United States, and is more prevalent than diabetes or cancer (1). Occupational hearing loss, primarily caused by high noise exposure, is the most common U.S. work-related illness (2). Approximately 22 million U.S. workers are exposed to hazardous occupational noise (3). CDC compared the prevalence of hearing impairment within nine U.S. industry sectors using 1,413,789 noise-exposed worker audiograms from CDC’s National Institute for Occupational Safety and Health (NIOSH) Occupational Hearing Loss Surveillance Project (4). CDC estimated the prevalence at six hearing impairment levels, measured in the better ear, and the impact on quality of life expressed as annual disability-adjusted life years (DALYs), as defined by the 2013 Global Burden of Disease (GBD) Study (5).

The mining sector had the highest prevalence of workers with any hearing impairment, and with moderate or worse

References

http://www.cdc.gov/niosh/topics/surveillance/default.html.
impairment, followed by the construction and manufacturing sectors. Hearing loss prevention, and early detection and intervention to avoid additional hearing loss, are critical to preserve worker quality of life.

The NIOSH Occupational Hearing Loss Surveillance Project collects de-identified audiograms* for U.S. workers (4) who were tested to comply with regulatory requirements because of high occupational noise exposure, defined as ≥85 decibels on the A-scale (dBA).† Audiometric service providers and others that perform worker testing agreed to share these data with NIOSH. A cross-sectional retrospective cohort analysis was conducted using the last audiogram completed for each worker during 2003–2012. Audiograms missing necessary fields or with other quality issues, having hearing threshold values that suggested testing errors, or displaying attributes unlikely to be primarily caused by occupational exposures, were excluded (4). Industries were classified using the 2007 North American Industry Classification System.§

The prevalences of six severity levels of hearing impairment were calculated for workers in each industry sector using the audiometric definitions from the GBD Study (Table 1) (5), except that workers in this sample who had hearing aids did not wear them during testing. DALYs representing the number of healthy years lost per 1,000 workers each year were calculated by industry sector using the GBD Study disability weights (Table 1).

**  Tinnitus prevalences were estimated using results for U.S. noise-exposed workers with daily or more frequent tinnitus comorbid with hearing loss (http://onlinelibrary.wiley.com/doi/10.1002/ajim.22565/epdf) and proportions of the general population experiencing daily tinnitus by GBD Study level of hearing impairment (http://www.who.int/healthinfo/statistics/GlobalDALYmethods_2000_2011.pdf). Tinnitus prevalence estimates for each level of hearing impairment severity for the DALY calculations were as follows: mild (18.40%); moderate (26.58%); moderately severe (28.61%); severe (55.79%); profound (26.58%); moderately severe (28.61%); severe (55.79%); profound (26.58%); complete (47.97%).

The final sample included 1,413,789 audiograms for workers employed by 25,908 U.S. companies during 2003–2012. Among 99% of audiograms for which information on the worker’s sex was available, 78% were recorded for males and 22% for females. A greater percentage of males had any hearing impairment (14%) than did females (7%), and the prevalence and severity of impairment increased with age (Table 2) for males.

For morbid conditions, such as hearing impairment, the burden over a one-year period is represented by a “disability weight” between 0 and 1, representing life limitations as a lost fraction of a year of healthy life. Because the most recent audiograms for workers were used to characterize hearing impairment, the DALY results are an estimate of the annual number of DALYs per 1,000 workers in the year of the last audiogram, and a minimum estimate of DALYs in following years. Thus, the DALY results are estimates of the annual DALYs per 1,000 workers as of 2012, the last year included in the analysis.

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TABLE 1. Hearing impairment audiometric definitions, and Global Burden of Disease (GBD) Study disability weights and lay descriptions

<table>
<thead>
<tr>
<th>Severity of hearing impairment</th>
<th>Audiometric definition*</th>
<th>GBD Study disability weight (no tinnitus)</th>
<th>GBD Study disability weight (with tinnitus)</th>
<th>GBD Study lay description (no tinnitus)</th>
<th>GBD Study lay description (with tinnitus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>20–34 dB average hearing threshold level across 500, 1,000, 2,000, and 4,000 Hz in the better ear</td>
<td>0.01</td>
<td>0.021</td>
<td>Has great difficulty hearing and understanding another person talking in a noisy place (for example, on an urban street)</td>
<td>Has great difficulty hearing and understanding another person talking in a noisy place (for example, on an urban street), and sometimes has annoying ringing in the ears</td>
</tr>
<tr>
<td>Moderate</td>
<td>35–49 dB average hearing threshold level across 500, 1,000, 2,000, and 4,000 Hz in the better ear</td>
<td>0.027</td>
<td>0.074</td>
<td>Is unable to hear and understand another person talking in a noisy place (for example, on an urban street), and has difficulty hearing another person talking even in a quiet place or on the phone</td>
<td>Is unable to hear and understand another person talking in a noisy place (for example, on an urban street), has difficulty hearing another person talking even in a quiet place or on the phone, and has annoying ringing in the ears for 5 minutes at a time, almost every day</td>
</tr>
<tr>
<td>Moderately severe</td>
<td>50–64 dB average hearing threshold level across 500, 1,000, 2,000, and 4,000 Hz in the better ear</td>
<td>Not calculated by GBD Study</td>
<td>Not calculated by GBD Study</td>
<td>Not generated by the GBD Study</td>
<td>Not generated by the GBD Study</td>
</tr>
<tr>
<td>Severe</td>
<td>65–79 dB average hearing threshold level across 500, 1,000, 2,000, and 4,000 Hz in the better ear</td>
<td>0.158</td>
<td>0.261</td>
<td>Is unable to hear and understand another person talking, even in a quiet place, and unable to take part in a phone conversation. Difficulties with communicating and relating to others cause emotional impact at times (for example, worry or depression)</td>
<td>Is unable to hear and understand another person talking, even in a quiet place, is unable to take part in a phone conversation, and has annoying ringing in the ears for more than 5 minutes at a time, almost every day. Difficulties with communicating and relating to others cause emotional impact at times (for example, worry or depression)</td>
</tr>
<tr>
<td>Profound</td>
<td>80–94 dB average hearing threshold level across 500, 1,000, 2,000, and 4,000 Hz in the better ear</td>
<td>0.204</td>
<td>0.277</td>
<td>Is unable to hear and understand another person talking, even in a quiet place, is unable to take part in a phone conversation, and has great difficulty hearing anything in any situation. Difficulties with communicating and relating to others often cause worry, loneliness</td>
<td>Is unable to hear and understand another person talking, even in a quiet place, is unable to take part in a phone conversation, has great difficulty hearing anything in any situation, and has annoying ringing in the ears for more than 5 minutes at a time, several times a day. Difficulties with communicating and relating to others often cause worry, depression or loneliness</td>
</tr>
<tr>
<td>Complete</td>
<td>95 dB or greater average hearing threshold level across 500, 1,000, 2,000, and 4,000 Hz in the better ear</td>
<td>0.215</td>
<td>0.316</td>
<td>Cannot hear at all in any situation, including even the loudest sounds, and cannot communicate verbally or use a phone. Difficulties with communicating and relating to others often cause worry, loneliness</td>
<td>Cannot hear at all in any situation, including even the loudest sounds, and cannot communicate verbally or use a phone, and has very annoying ringing in the ears for more than half of the day. Difficulties with communicating and relating to others often cause worry, depression or loneliness</td>
</tr>
</tbody>
</table>

Abbreviations: dB = decibel; Hz = hertz.
* These are the same as GBD Study audiometric definitions, except that the workers in this sample with hearing aids did not wear them during testing.
† dB is a unit of measure of the intensity (or loudness) of a sound.

both sexes. Among all industries, 13% of noise-exposed workers had any impairment and 2% had moderate or worse impairment (Table 3). Workers with hearing impairment were represented in all industry sectors, with sharply decreasing numbers of workers with higher levels of impairment. The mining sector had the highest prevalence of workers with any impairment (17%) and with moderate or worse impairment (3%), followed by the construction sector (any impairment = 16%, moderate or worse impairment = 3%), and the manufacturing sector (14% and 2%). The public safety sector, which includes police protection, fire protection (including wildland firefighters), corrections, and ambulance services, had the lowest prevalence of workers with any impairment (7%).

Across all industries, 2.53 healthy years were lost annually per 1,000 noise-exposed workers (Table 3). Mild impairment accounted for 52% of all healthy years lost and moderate impairment accounted for 27%. Workers
in the mining and construction sectors lost 3.45 and 3.09 healthy years per 1,000 workers, respectively. Overall, 66% of the sample worked in the manufacturing sector and represented 70% of healthy years lost by all workers.

Public safety workers lost 1.30 healthy years per 1,000 workers, the fewest among all workers.

### Discussion

Findings of increasing prevalence with age and a higher prevalence among males were expected and consistent with other research (2,4,8). Industry results highlight the high prevalence of hearing loss within the noise-exposed working population.
and the need for continued prevention efforts, especially in the mining, construction, and manufacturing sectors. The proportion of mining sector employees exposed to hazardous noise (76%) was the highest in any sector (3), and studies have consistently indicated elevated risks for occupational hearing loss within this sector (2, 4). Occupational hearing loss risks have also been established within the construction sector (2, 4); however, current noise regulations do not require audiometric testing for construction workers (2). Without testing to identify workers losing their hearing, intervention might be delayed or might not occur. Although a comparatively smaller percentage of manufacturing workers are noise-exposed (37%), this sector accounts for the most noise-exposed workers in the United States (3), and, as expected, the largest number of workers with hearing impairment. Some manufacturing sub-sectors, such as wood product, apparel, and machinery manufacturing, have been found to have occupational hearing loss risks as high as those in the mining and construction sectors (4). Another study using earlier GBD Study hearing impairment definitions also found the heaviest burdens of hearing impairment were in the mining, construction, and manufacturing sectors, indicating the most healthy years were lost in these sectors (8).

Approximately 78% of the healthy years lost were attributable to mild or moderate hearing impairment. Preventing any occupational hearing loss is the best way to reduce worker hearing impairment over a lifetime, because even mild-to-moderate impairment during working years can culminate into more healthy years lost during retirement. Prevention also has short-term benefits; persons with even mild hearing loss experience reduced audibility (loudness), reduced dynamic range of hearing (the difference between the softest and loudest perceptible sounds), and increased listening fatigue (2). They also often experience difficulties understanding speech, especially in the presence of background noise (2). Other effects include degraded communication (2), cognitive decline (9), and depression (2).

In the general population, the prevalence of impairment also sharply decreases at higher levels of impairment, and severe impairment is not typically caused exclusively by noise. Some workers with a substantial hearing impairment might transfer...
Summary
What is already known about this topic?
Hearing loss is prevalent in the United States, especially among noise-exposed workers.
What is added by this report?
This is the first known study to quantify the disability-adjusted life years attributable to hearing impairment for noise-exposed U.S. workers, and to estimate the prevalence at each level of hearing impairment by industry sector.
What are the implications for public health practice?
Prevention, early detection, and intervention to preclude additional hearing loss are essential to reducing worker disability caused by hearing impairment.

Owing to noise-related occupational hearing loss, workers may be prevented from engaging in work activities and thereby experience a substantial impact on productivity and safety. For example, although the public safety sector had fewer older workers (lowering the prevalence), hearing impairment might have resulted in attrition because of the hearing-critical nature of many occupations in this sector (2).

The findings in this report are subject to at least seven limitations. First, this was a convenience sample and might not be representative of all noise-exposed workers tested in the United States. Second, not all noise-exposed workers are tested in the United States, especially in industries with high proportions of mobile or temporary workers, such as the construction and agriculture sectors. Third, in the absence of additional information, such as medical records, hearing impairment caused by occupational exposures can only be inferred. However, this inference was strengthened by studying exposed workers and excluding audiograms indicating nonoccupational exposures. Fourth, GBD Study disability weights were developed using international surveys asking respondents to compare life limitations posed by different health conditions, and to compare the value of preventing certain health conditions to the value of preventing death (5); respondents might not be able to appreciate the impact a disability can have on quality of life if they do not have that disability. Fifth, GBD Study audiometric definitions for impairment levels are conservative, with stringent requirements to reach even mild impairment. In addition, no impairment is identified when there is a total loss of hearing in one ear, and the impairment in the other ear can be lessened by hearing aid use. These limitations might have lowered impairment estimates, and worker impairment might be higher than reported here. Sixth, workers in the Occupational Hearing Loss Surveillance Project who wear hearing aids did not wear them during testing. However, few persons wear hearing aids during working years (9), so no adjustments were made for hearing aid use. Finally, no information was available on other conditions, so healthy years lost because of hearing impairment were not adjusted for comorbidities (5).

Occupational hearing loss is a permanent but entirely preventable condition with today’s hearing loss prevention strategies and technology (2). Concurrent with prevention efforts, early detection of hearing loss by consistent annual audiometric testing, and intervention to preclude further loss (e.g., refitting hearing aids, training), are critical. Although lost hearing cannot be recovered, workers can benefit from clinical rehabilitation, which includes fitting hearing aids, learning lip-reading, and adopting other compensation strategies to optimize hearing. Study results support beginning rehabilitation at a mild level of hearing impairment. Prevention, and early detection, intervention, and rehabilitation, might greatly improve workers’ quality of life (2,9).

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References